

Ultrapure Water (UPW) Cleaning and Assembling of Genesis Mission Payload in ISO Class 4

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Genesis Solar Wind Sample Return Mission

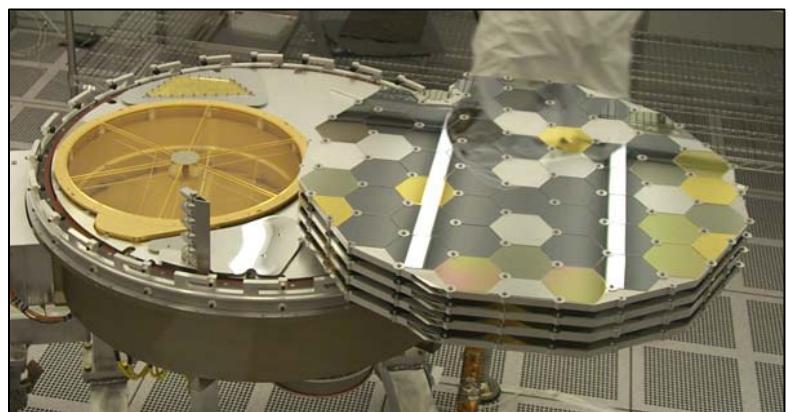
Purpose: Collect solar wind ions to enable laboratory measurement of the elemental and isotopic composition of the Sun with enough precision for planetary science.

Launched: August 8, 2001

Collection: On pure materials exposed 27 months at Earth-Sun L1

Recovered: September 9, 2004

<http://curator.jsc.nasa.gov/genesis/index.cfm>



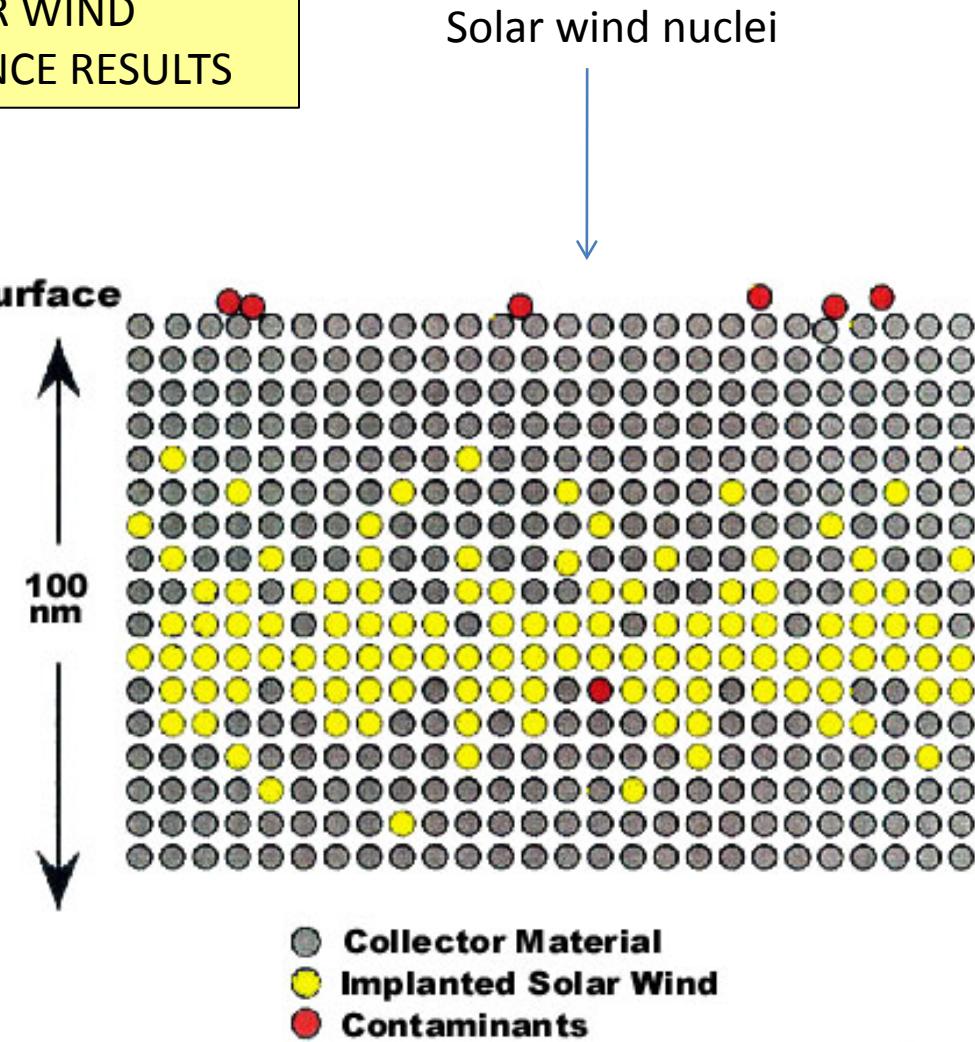


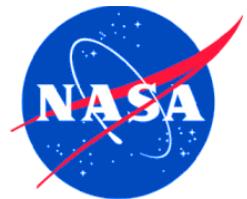
CLEANLINESS OF PAYLOAD AND SOLAR WIND COLLECTORS WAS CRITICAL FOR SCIENCE RESULTS

- Collector materials are “containers” which will capture solar wind
- Must be pure
- Must be clean

CONTAMINATION SOURCES:

- Ground handling
- Outgassing
- Micrometeoroid impacts
- Station-keeping thrusters
- Re-entry re-pressurization



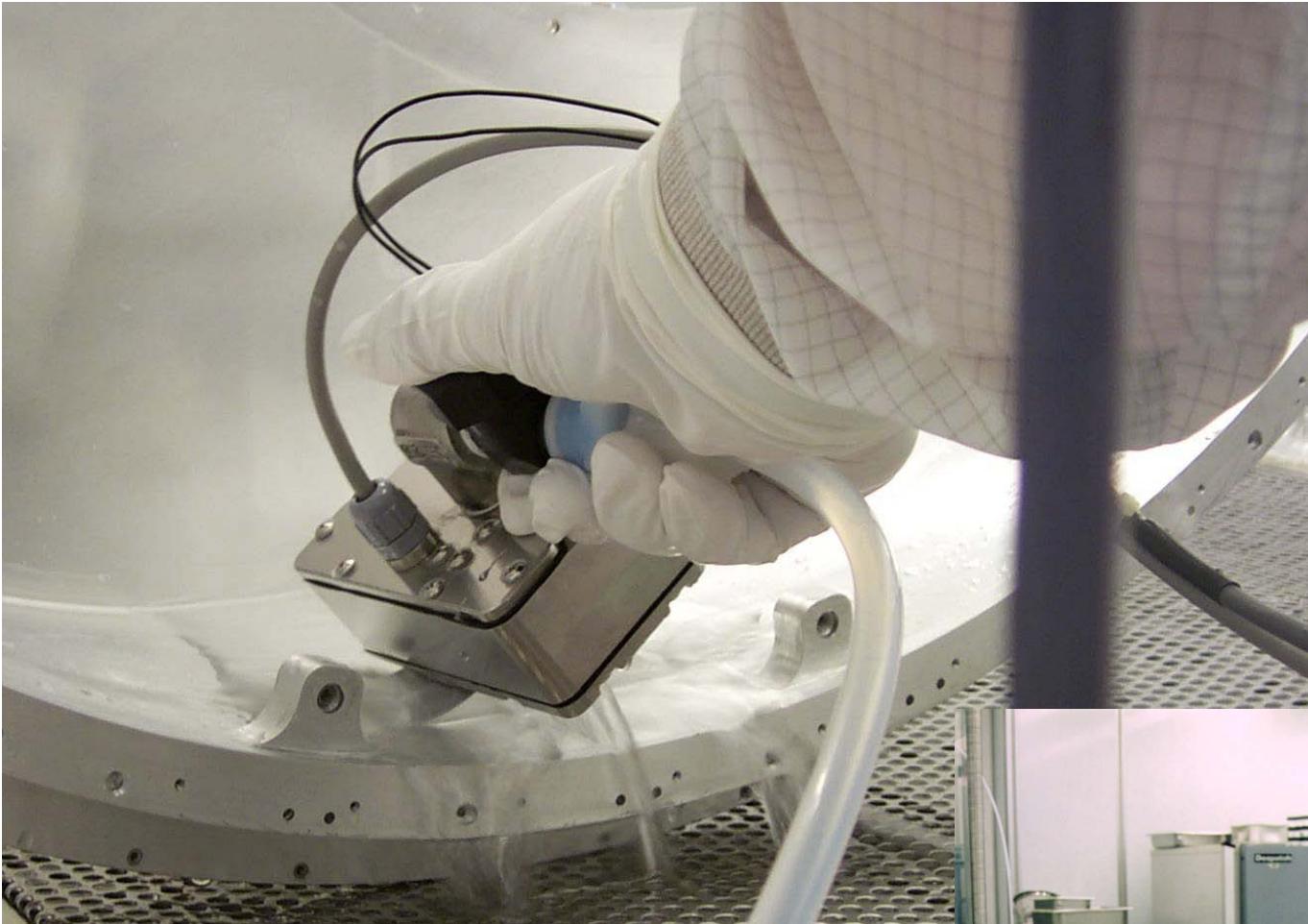


CLEANING PAYLOAD PRIOR TO FLIGHT

- Cleaned and assembled in ISO Class 4 room
- UPW for cleaning is resistivity $18.2 \text{ M}\Omega\text{-cm}$
- Hardware cleaned to particle levels 25 to 50
- Airborne molecular contamination measured by polished silicon witness plates – 10 ng/cm^2
- Minimal use of lubricants (applied with dental pick), lubricated parts were isolated from collectors
- Closed in ISO Class 4, not opened again until on station at Earth-Sun L1

CLEANING COLLECTORS AFTER CRASH

- UPW used on request
- UV ozone to remove polymerized contaminant layer



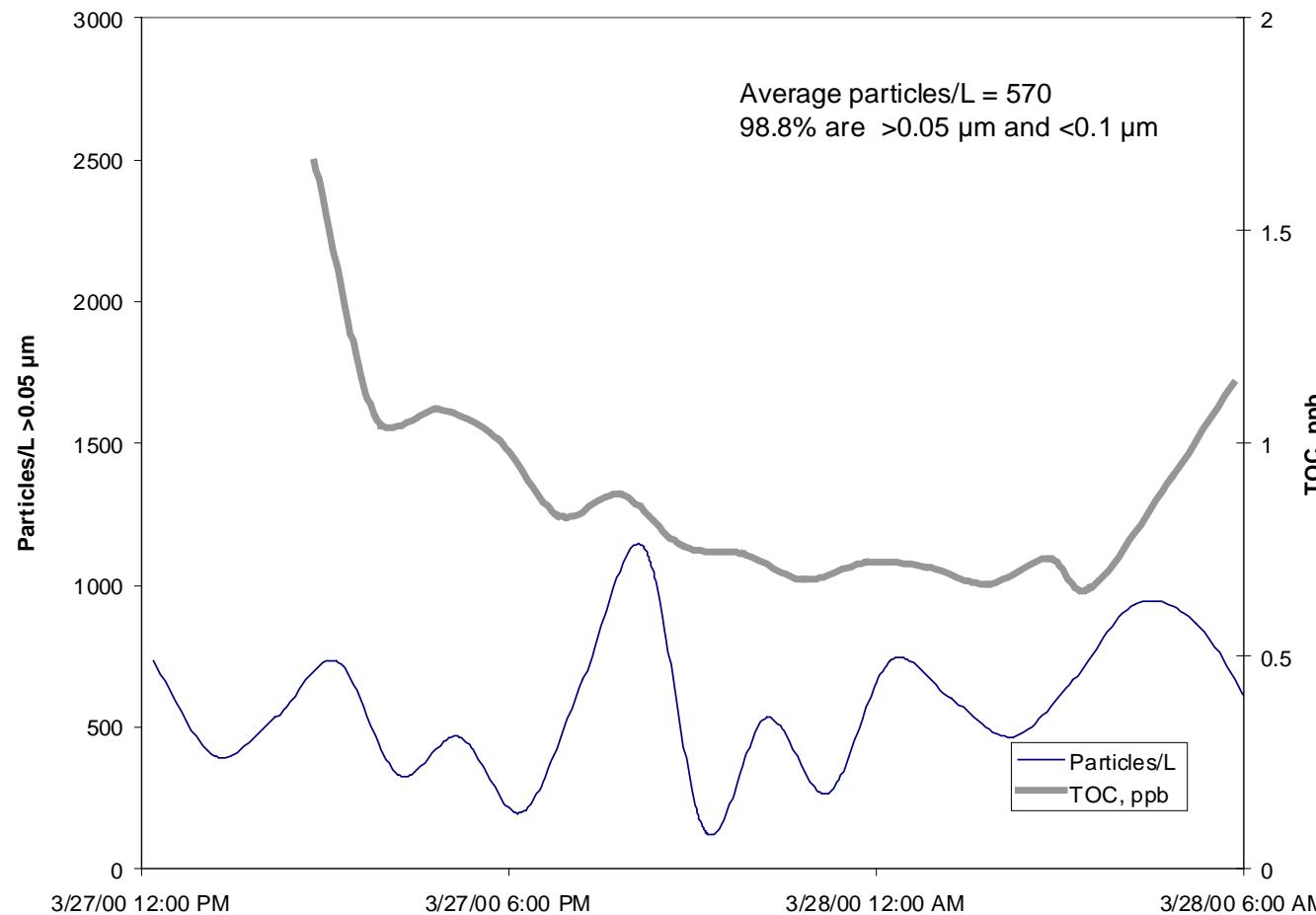
Cleaning payload with ultrapure water (UPW)

- Use of megasonic energy (above)
- Use of ultrasonic energy (tank)
- High purity water is an aggressive cleaner



JSC UPW particle and TOC trends

18-hour TOC & Particle Trend



UNITS: Particles > 50 nm concentration per liter; Total Oxidizable Carbon in ppb

SOURCE: High Purity Water Used for Moon and Mars Specimen Curation At the Johnson Space Center, Houston, Texas
Presented at: Ultrapure Water '2000, Philadelphia, PA, April 11-13, 2000

JSC UPW Chemistry – Units are parts per trillion, below detection limit
 Resistivity 18.2 MΩ-cm

<u>PARAMETER</u>	<u>CONCENTRATION</u> <u>PPT</u>
Dissolved silica	<100
Anions by IC	
Fluoride (F-)	<100
Chloride (Cl-)	<200
Nitrite (NO2-)	<20
Bromide (Br-)	<20
Nitrate (NO3-)	<20
Phosphate (HPO4=)	<20
Sulfate (SO4=)	<50

<u>PARAMETER</u>	<u>CONCENTRATION</u> <u>PPT</u>
Monovalent & Divalent Cations by IC	
Lithium (Li+)	<10
Sodium (Na+)	<10
Ammonium (NH4+)	<50
Potassium (K+)	<20
Magnesium (Mg++)	<20
Calcium (Ca++)	<20

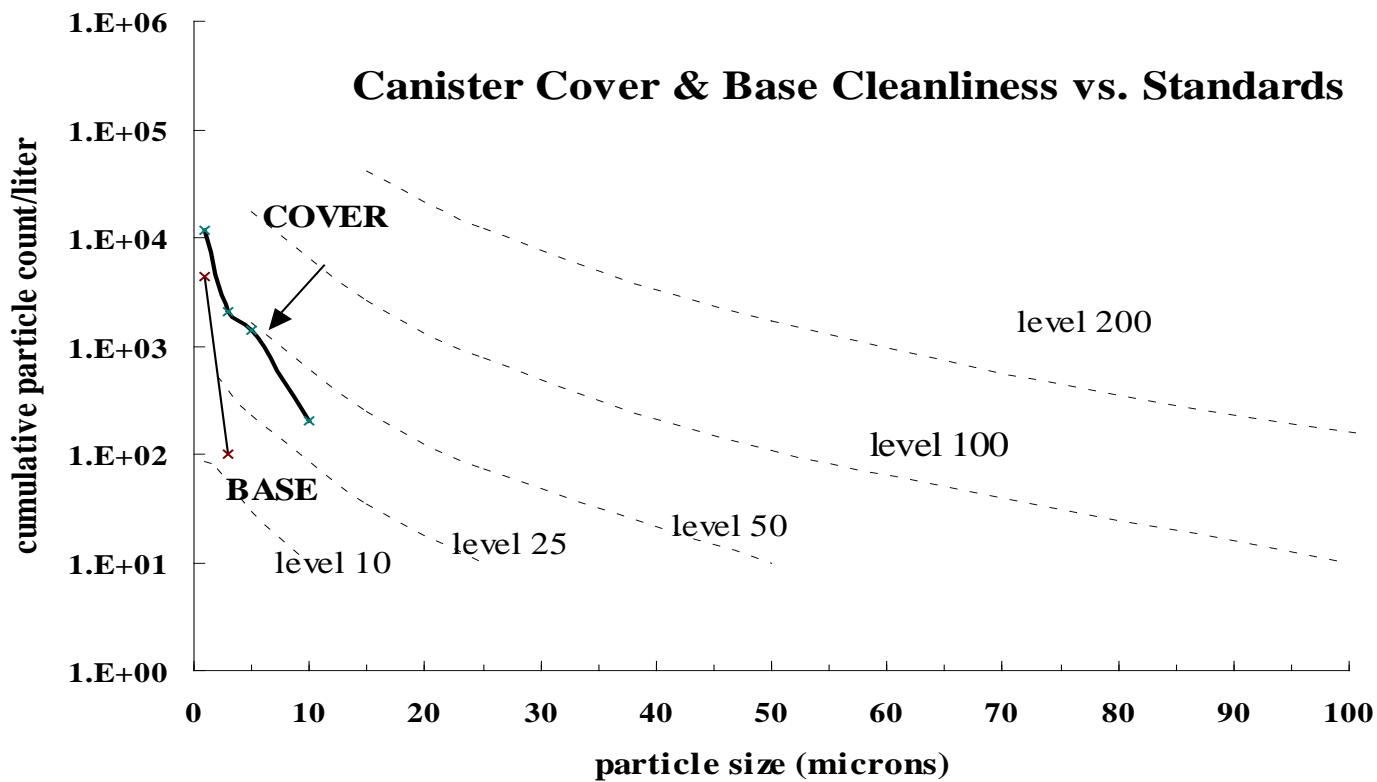
JSC UPW Chemistry – Units are parts per trillion, below detection limit (except boron)
Resistivity 18.2 MΩ-cm

30 Elements in UPW	
Aluminum (Al)	<2
Antimony (Sb)	<2
Arsenic (As)	<3
Barium (Ba)	<0.5
Beryllium (Be)	<1
Bismuth (Bi)	<1
Boron (B)	2100
Cadmium (Cd)	<3
Calcium (Ca)	<20
Chromium (Cr)	<3
Cobalt (Co)	<0.5
Copper (Cu)	<2
Gallium (Ga)	<0.5
Germanium (Ge)	<3
Iron (Fe)	<10
Lead (Pb)	<1
Lithium (Li)	<1
Magnesium (Mg)	<2
Manganese (Mn)	<2
Molybdenum (Mo)	<4
Nickel (Ni)	<2
Potassium (K)	<10
Silver (Ag)	<1
Sodium (Na)	<5
Strontium (Sr)	<0.5
Tantalum (Ta)	<2
Tin (Sn)	<3
Titanium (Ti)	<2
Vanadium (V)	<1
Zinc (Zn)	<5

SOURCE: J. H. Allton et al. (2002) Cleaning Genesis Sample Return Canister for Flight: Lessons for Planetary Sample Return, JSC-29742.



Fig. 4-9. Canister base is rinsed with ultrapure water (UPW)



SOURCE: J. H. Allton et al. (2002) Cleaning Genesis Sample Return Canister for Flight: Lessons for Planetary Sample Return, JSC-29742.

- Ultrapure water is reactive
- Care must be used when cleaning bare aluminum

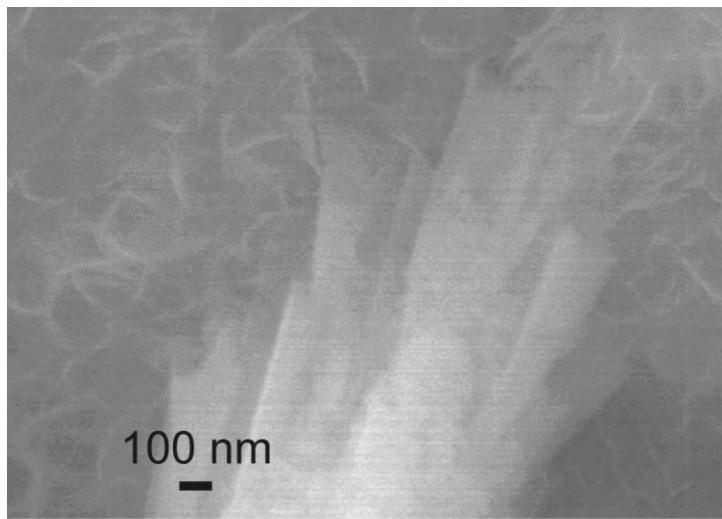


Fig. 4-6. The needle laths (bayerite?) radiating from single point. The view is from same coupon in fig. 4-5. Scale bar is 100nm.

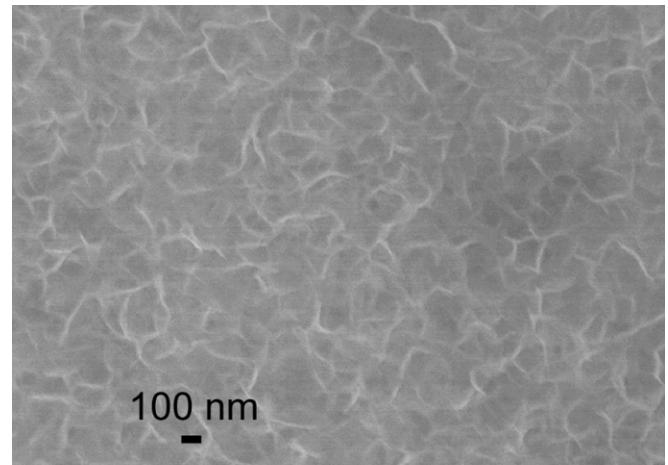


Fig. 4-5. The wrinkled texture of hydroxides (boehmite?) resulting from UPW cleaning of aluminum 6061 at 75°C for 30 min. Scale bar is 100 nm.

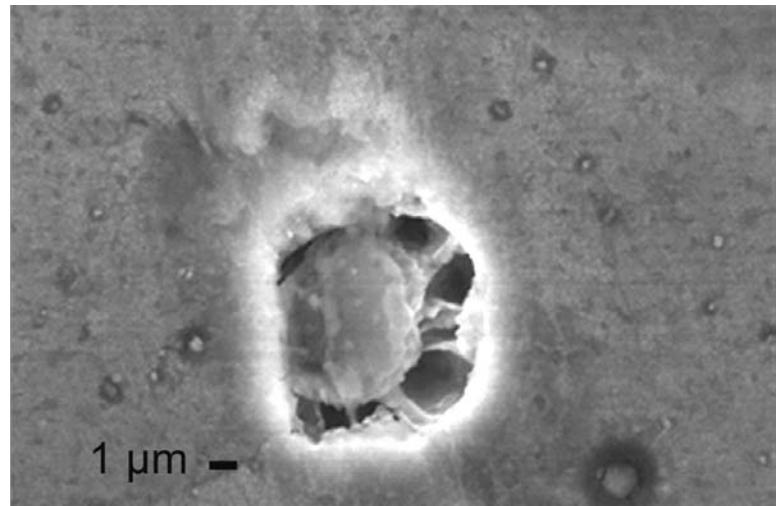


Fig. 4-7. Erosion pit around inclusion in aluminum 6061 cleaned in UPW at 50°C for 30 minutes. Scale bar is 1 μm.

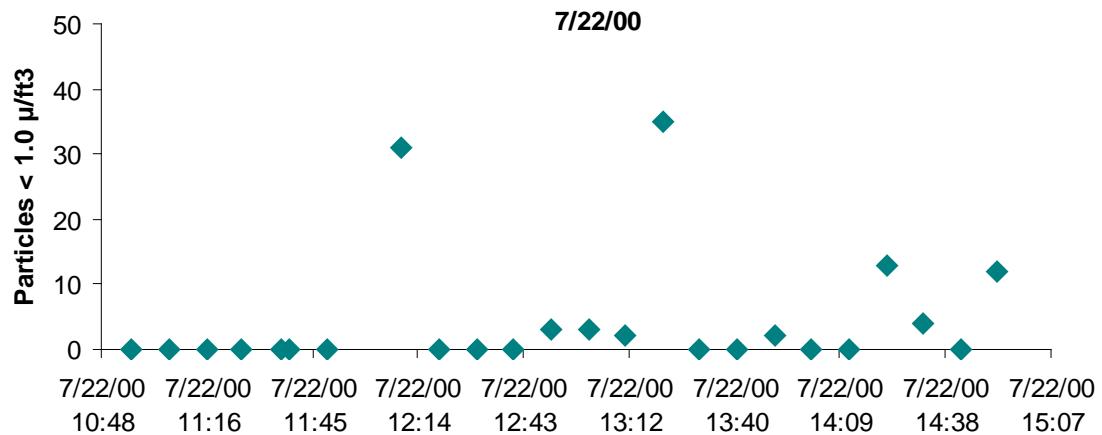
Assembled in ISO Class 4. Personnel wearing HEPA-filtered teflon suits



8/18/2000



Fig. 5-4. Dryden suit completely envelops person. Self-contained battery motor forces exhaled breath through HEPA filters.

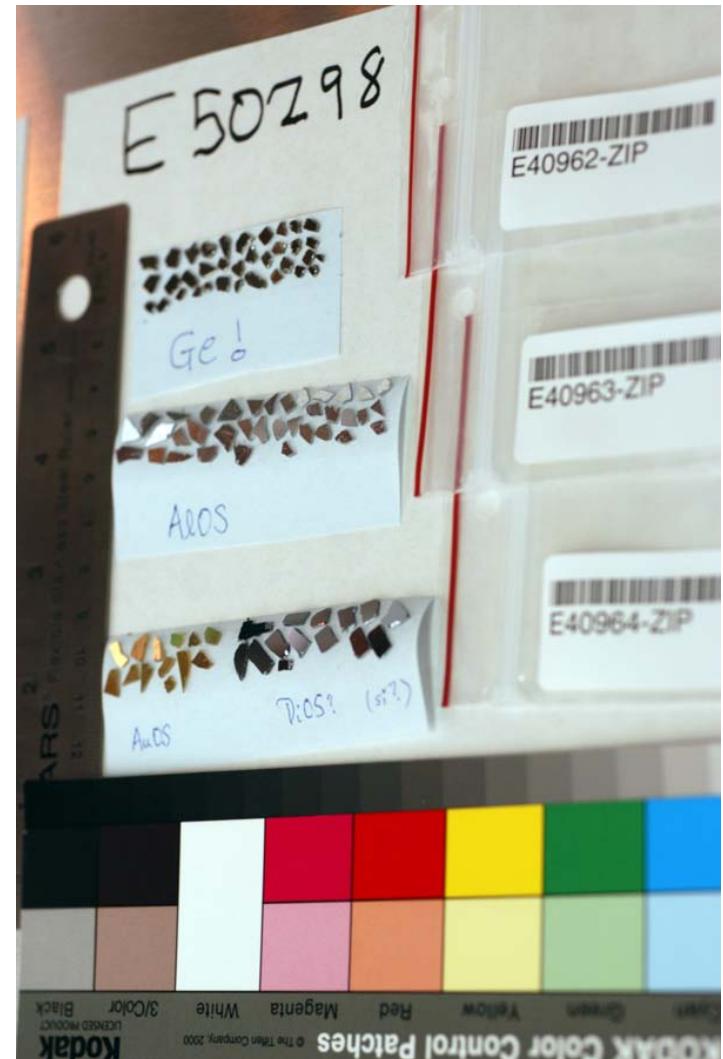
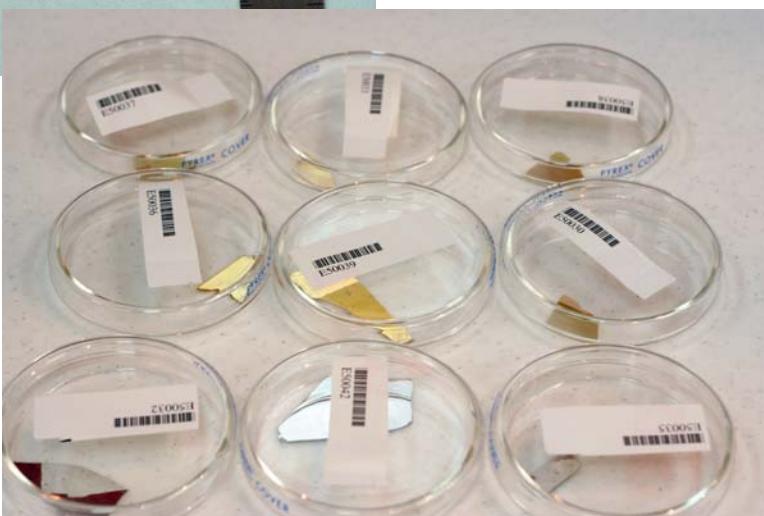


Particle counts for particles $< 1 \mu\text{m}$ per ft^3 taken directly downstream of activities show at left.

SOURCE: J. H. Allton et al. (2002) Cleaning Genesis Sample Return Canister for Flight: Lessons for Planetary Sample Return, JSC-29742.

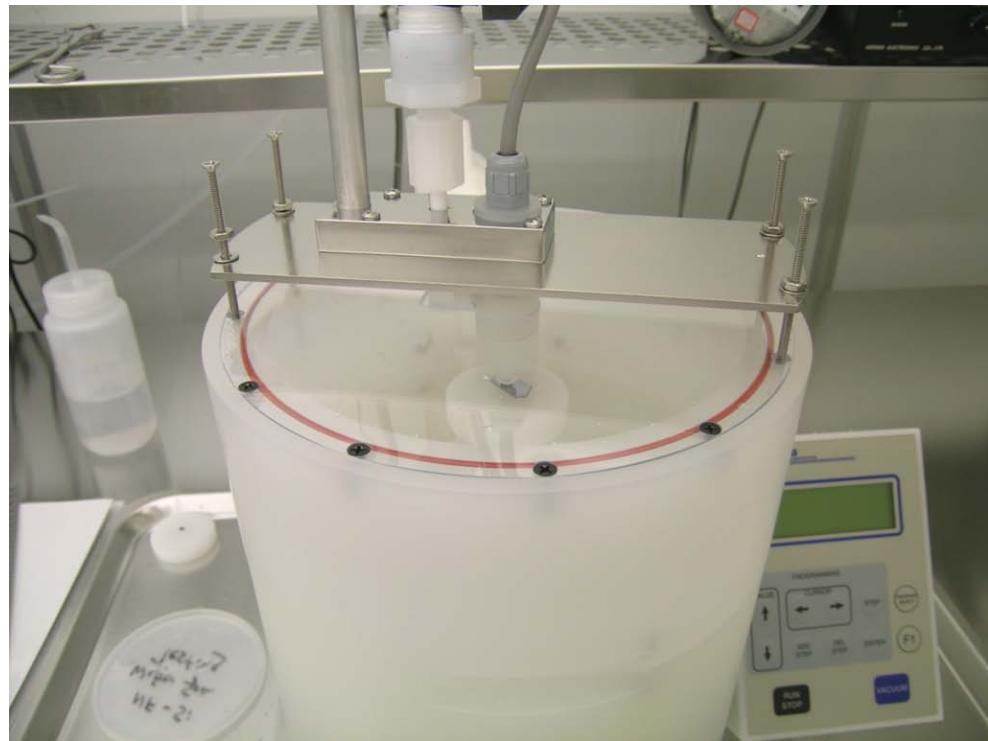
Postscript – after the crash, using UPW to clean solar wind samples







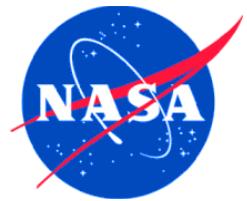
Samples held in place with vacuum chuck. Megasonically energized UPW flows onto the sample, spinning at 3000 rpm.



We integrated two existing technologies: a Laurell Technologies Corp. WS-400E-NPP-Lite Series Natural Polypropylene Single Wafer Spin Processor and the W-357P-25 megasonic cleaner.

Number of Particles	Clean Time			
	0 min.	5 min.	15 min.	30 min.
>30 µm diameter	492	6	7	7
10-30 µm diameter	1145	21	17	17
5-10 µm diameter	1869	86	78	89
1-5 µm diameter	13379	1187	1470	1237
0.3-1.0 µm diameter	10697	1400	2114	1600
Total Particle Count	27582	2700	3686	2950
% Particle Reduction		90.21%	86.64%	89.30%
Total Area of Particles (µm ²)	74537.55	16570.56	15504.54	15501.39
Surface Area Free of Contamination	93.20%	98.49%	98.59%	98.59%

SOURCE: M.J. Calaway (2009) DECONTAMINATING SOLAR WIND SAMPLES WITH THE GENESIS ULTRA-PURE WATER MEGASONIC WAFER SPIN CLEANER. Lunar and Planetary Science XL, abstract #1183
<http://www.lpi.usra.edu/meetings/lpsc2009/pdf/1183.pdf>



- UPW is an effective cleaner, leaves no residue
- Cleans stainless steel effectively, high temperatures may be used
- Can damage bare aluminum, low temperatures are needed
- Can assemble a payload in ISO Class 4.
- UPW is now used to clean solar wind samples

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THE SUN'S OXYGEN ISOTOPIC AND NITROGEN ISOTOPIC COMPOSITIONS HAVE BEEN MEASURED AND PUBLISHED –

THE #1 AND #2 SCIENCE GOALS OF GENESIS MISSION!